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Biology of the spineless cuttlefish *Sepiella inermis* (Orbigny, 1848) from Mumbai waters

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ABSTRACT

The relationship between dorsal mantle length (DML) and body weight (TW) of *Sepiella inermis* was Log TW = -2.8217 + 2.4474 log DML and Log TW = -3.1712 + 2.6808 log DML for males and females respectively. The species showed allometric growth and the regression coefficients were highly significant at 5% level for both the sexes. Crustacean remains was the dominant food item in the stomach followed by fish. High value of gastrosomatic index was recorded in August (13.06%) and low value was observed in March (5.93%). Sex ratio ranged between 1:1.10 (March) to 1:2.36 (June). 50% of the males matured at 48.06 mm and females matured at 55.04 mm. Fecundity ranged between 216 and 354 ova. Ovadiameter varied between 0.38 and 3.57 mm. Matured females occurred throughout the year with a primary peak in October followed by three secondary peaks in January, April and July-August, indicating four spawning seasons.

Keywords: Gut analysis, Length-weight relationship, Reproductive biology, *Sepiella inermis*

Introduction

The spineless cuttlefish, *Sepiella inermis* constitutes 2-4% of the total cephalopod landings of India (CMFRI, 2006). *S. inermis* is a demersal shallow water species with a wide distribution along the Indo-Pacific region (Roper *et al*., 1984). In Indian waters, it is widely distributed along both east and west coasts upto depths of about 40 m. Trawlers are the main gear used to capture *S. inermis*. In Kerala and Tamil Nadu, they are also caught by shore seines and boat seines (Silas *et al.*, 1982). Along the Mumbai coast, *S. inermis* is caught by the artisanal gear *dol* net and hand operated trawler nets. Studies on the biology of this species was carried out by Oommen (1977) from Cochin waters, Jothinayagam (1981) from Madras, Unnithan (1982) from Mandapam, Silas *et al.* (1985b) from Kakinada, Madras, Proto Novo, Waltair and Cochin, Appanna Sastry (1989) from Kakinada, Talukdar *et al*. (1995) from West Bengal, Sarvesan (1996) from Madras and Sivalingam (1999) and Neethiselvan *et al*. (2002) from Tuticorin.

Though *S. inermis* is an emerging species in the cuttlefish fishery from the shallow inshore waters, not much work has been carried out on this species from the west coast of India. Therefore, an attempt has been made to study the length-weight relationship, food and feeding and reproductive biology of *S. inermis* from Mumbai waters, north-west coast of India.

Materials and methods

During the period January 2001-December 2002, weekly samples of *S. inermis* were collected from the trawlers operated at New Ferry Wharf. The Dorsal Mantle Length (DML) and Body Weight (TW) measurements were taken as described in CMFRI (1995). Samples could not be collected for the month of July as mechanised trawling was suspended from 10th June to 15th August, due to the restrictions imposed by the government of Maharashtra during south-west monsoon season.

The length-weight relationship (L-W) (length in mm and weight in g), food and feeding habits and reproductive biology of 566 males (21 - 69 mm, DML) and 537 females (20 - 83 mm, DML) were analysed. Studies on 123 specimens of indeterminants (5 - 20 mm, DML) were also carried out. The sex-ratio was determined for the period January 2001-December 2003, based on random selection of 12,144 individuals (males: 5,090 and females: 7,054) measuring between 17 and 70 mm and between 17 and 90 mm for males and females, respectively.

Length-Weight relationships were obtained with the regression equation $W = a * L^b$ (Le Cren, 1951). To find out difference between L-W relationship of males and females, regression coefficients were tested by 't' test described by Zar (1999). To test the equality of correlation coefficient 'b', 't' test was followed.

The stomach condition was divided into six stages such as 'full', '¾ full', '½ full', '¼ full', 'trace' and 'empty' as per Kore and Joshi (1975). The feeding intensity was calculated by the 'points' method (Hynes, 1950) and the index of preponderance was estimated as suggested by Natarajan and Jhingran (1961). Apart from these, monthly gastrosomatic index was also estimated.

Reproductive studies were carried out according to Silas *et al.* (1985a). The animals were classified into four maturity stages, immature (stage I), maturing (stage II), mature (stage III) and gravid or ripe (stage IV). The size at first maturity was estimated by King's (1995) method. To estimate the fecundity, ovaries were removed from the fresh specimens and a few drops of formalin (4%) were added and teased to facilitate easy separation. Ovadiameter measurements were made according to Prabhu (1956). Apart from these parameters, sex ratio (the proportion of males and females was statistically tested against an expected 1:1 ratio by Chi-square test at 5% significance level), maturity, spawning population, spawning season, spawning frequency, gonadosomatic index [(ovary weight/ total weight) x 100], nidamental gland index [(nidamental glands weight / total weight) x 100] and hepatic index [(hepatic organ weight/ total weight) x 100] were estimated.

Results

Length-weight relationship

The regression coefficient values obtained for the length-weight relationship of males and females were significantly different ($p<0.05$). Therefore, common expressions cannot be used. The 't' test indicated that the 'b' value significantly ($p<0.05$) departed from the isometric value for males, females and indeterminants respectively. The relationships are expressed mathematically as :

Male: $TW = 0.001507648 * DML^{2.4474}$ ($r^2 = 0.9019$)

Female: $TW = 0.000674217 * DML^{2.6808}$ ($r^2 = 0.9260$)

Indeterminants: $TW = 0.001189049 * DML^{2.3422}$ ($r^2 = 0.8593$)

Food and feeding

The month-wise and size group-wise indices of preponderance are given in Table 1. The food items were in well crushed and macerated condition, therefore they were categorised into groups, such as 'crustacean remains', 'fishes', 'cephalopods', and 'digested matter'. Month-wise analysis of stomach contents of *S. inermis* revealed that 'crustacean remains' formed the major constituent in all the months with dominance in January. The monthly percentage occurrence of 'fish' exhibited considerable variation. The maximum amount of 'crustacean remains' was observed in January and very high feeding intensity was also observed during this month. The dominance of 'crustacean remains' was reduced during May and September. 'Fish' was the dominant group in September which was very less in January. In May, they consumed 'crustacean remains' and 'fish' in equal quantities. 'Cephalopod' parts were observed in small quantities in January, March and April, hence cannibalism appears to be occasional. In indeterminants, the gut was dominated by 'digested matter' followed by 'crustacean remains'.

Table 1. Month-wise and size group-wise indices of preponderence (%) of *S. inermis*

Months	Crustacean remains	Fish	Cephalopods	Digested matter
January	96.57	3.08	0.04	0.31
February	72.64	24.55	0.00	2.81
March	85.04	13.33	0.23	1.40
April	81.84	17.25	0.07	0.84
May	52.43	47.12	0.00	0.45
June	89.20	9.15	0.00	1.65
August	76.94	21.54	0.00	1.52
September	35.42	63.12	0.00	1.46
October	71.62	26.56	0.00	1.82
November	74.84	19.23	0.00	5.92
December	84.92	11.92	0.00	3.15
Size group (mm)				
05 - 19	31.57	0.00	0.00	68.43
20 - 39	79.21	18.67	0.00	2.12
40 - 54	80.68	17.74	0.01	1.58
55 - 69	73.24	25.66	0.01	1.09
70 - 89	85.18	14.02	0.64	0.16

There appeared to be some food preference by different length groups of *S. inermis*. 'Crustacean remains' constituted the important item of diet and were preferred by all length groups. 'Fish' exhibited considerable variation among the size groups and they were minimum in the size group 70-84 mm and were maximum in the size group 55-69 mm. In immature (20-39 mm), maturing (40-54 mm) and mature (55-69 mm) cuttle fishes, the diet included 'crustacean remains', 'fishes' and very rarely 'cephalopods'. 'Cephalopod' parts were observed in small quantities in higher size group of 70-84 mm (spent), hence cannibalism appears to be prevalent in larger animals. In indeterminants (5-19 mm), 'digested matter' dominated, followed by 'crustacean remains'.

Monthwise analysis revealed that the species was an active feeder in March and September with maximum feeding in January (17%). They were moderate feeders in February (32%). Overall, *S. inermis* is a poor feeder throughout the year and very poor feeding was observed in March (54%), September (65%) and December (67.5%). Empty stomach was the least in March and was very high in October with 44% (Fig. 1).

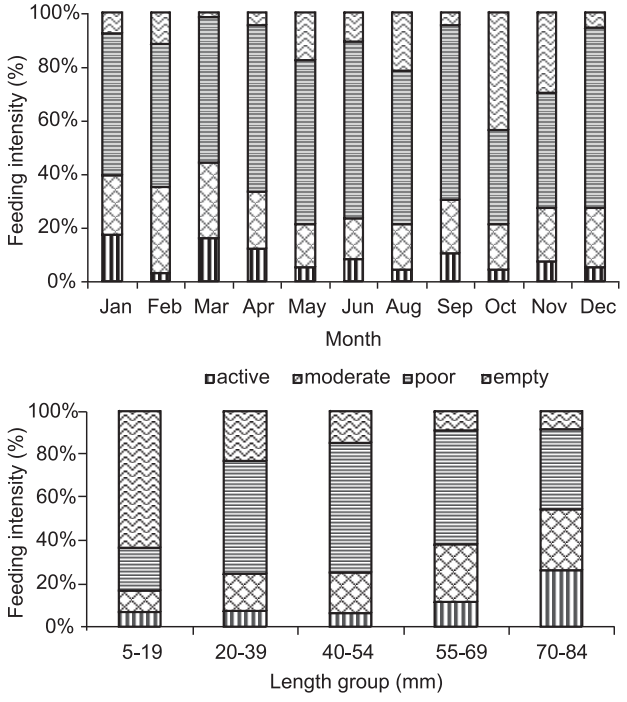

Fig. 1. Monthwise and sizewise feeding intensity of *S. inermis*

There is no definite trend in feeding intensity of *S. inermis* and there are wide fluctuations in the percentage occurrence of degree of fullness of stomachs in different length groups. The maximum number of 'empty' stomachs was observed in the length group 20-39 mm (23.2%) and 'trace' condition was also maximum in 20-39 mm group (21%). Throughout the year, '¼ full' stomach dominated in all size groups. '½ full' ranged between 14.3% (20-39 mm) and 17.2% (70-84 mm). '¾ full' and 'gorged' was maximum in 70-84 mm group with 11.4% and 25.7% respectively. In indeterminants, 63.4% of the stomachs were 'empty' and only 2.5% were in '¾ full' condition. 'Active 'and 'moderate' feeding in *S. inermis* was high in 70-84 mm group, very poor in the length group 40-54 mm (60.2%) and many empty stomachs were found in the length group 20-39 mm (23.2%).

The monthly gastrosomatic index values indicated a steep increasing trend from January onwards and reached a maximum in March with a minor peak in February, which further dipped and again reached a maximum in August. Thereafter a decrease was evident upto December with a slight increase in October. The gastrosomatic index showed four peaks; February (8.15%), May (12.96%), August (13.06%) and October (12.02%).

Sex ratio

It was observed that females were dominant throughout the year. The sex ratio (male: female) ranged between 1:1.10 (March) to 1:2.36 (June). The sexes were significantly different ($p < 0.05$) throughout the year except in March.

Maturity studies and size at first maturity

The peak occurrence of mature males was in April (53.3%), August (51.7%) and November (56%) and the

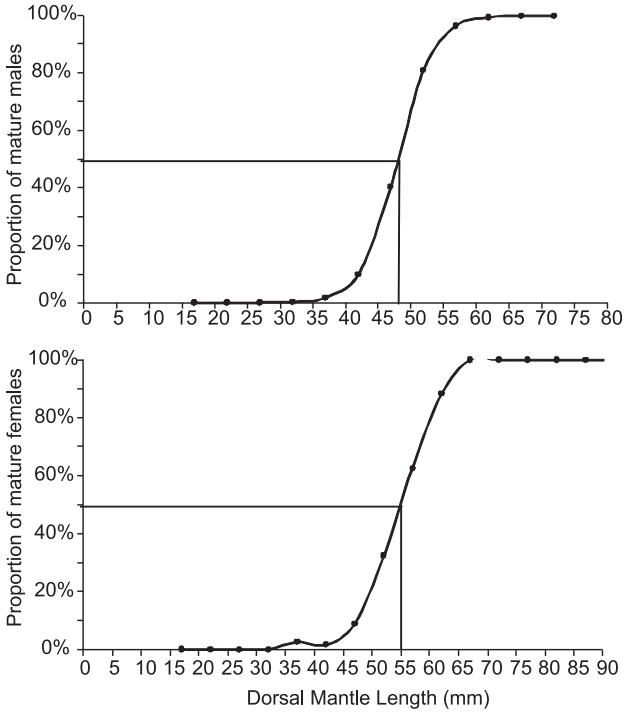

Fig. 2. Size at first maturity of males and females of *S. inermis*

peak occurrence of mature females was in October (66.7%) January (56.3%), and April (44.7%). Below 29 mm, all the males and females were in stage I while beyond 75 mm they were in stage IV. The smallest mature male and female were recorded at 31 mm and 35 mm respectively. The maturity curve showed that 50% of the males matured at 48.06 mm and females matured at 55.04 mm (Fig. 2).

Spawning population and spawning season

Males of length range 45-69 mm and females of length range 55-79 mm form the spawning population caught in trawlers from Mumbai waters. Though the matured animals occurred throughout the year, a primary peak of mature females was observed in October, followed by three secondary peaks in January, April and August, indicating that the species has four spawning seasons in a year.

Ova diameter and spawning frequency

The ova diameter ranged between 0.38 to 3.57 mm. The frequency polygon shows a mode at larger ova diameter of 3.0-3.2 mm at stage III maturity (Fig. 3).

Fecundity

Mature ova of individual specimens were counted and it was observed that the fecundity ranged from 216 to 354 ova. The relationship between fecundity (F) and dorsal mantle length (DML), fecundity and body weight (TW) are expressed mathematically as:

$F = - 215.698 + 7.9332_{*} DML \qquad (r^2 = 0.9075)$

$F = 153.697 + 2.7504_{*} TW \qquad (r^2 = 0.6533)$

Gonadosomatic Index (GSI)*, Nidamental gland Index* (NGI) *and Hepatic Index* (HI)

The GSI for males were more or less same with slight fluctuations throughout the year with a sharp dip during April-June. The GSI values for females indicated increasing trend from August onwards and reached a maximum in October, which further dipped and again reached a maximum in January. Thereafter a steep decrease was evident upto June with a slight increase in April. The NGI values indicated increasing trend from August onwards and reached a maximum in October, which further dipped and again reached a maximum in January. Thereafter, a steep decrease was evident upto June with a slight increase in April. The HI values indicated increasing and decreasing trends throughout the year with three major dips in January, April, July-August and October (Table 2).

Discussion

The 'r^2' values of the length-weight relationship of *S. inermis* are highly correlated to each other and the 'b' values were also high. It can be inferred that this species follows allometric growth. Females tend to gain more weight, which is in agreement with that observed by Unnithan (1982), Appanna Sastry (1989) and Sarvesan (1996).

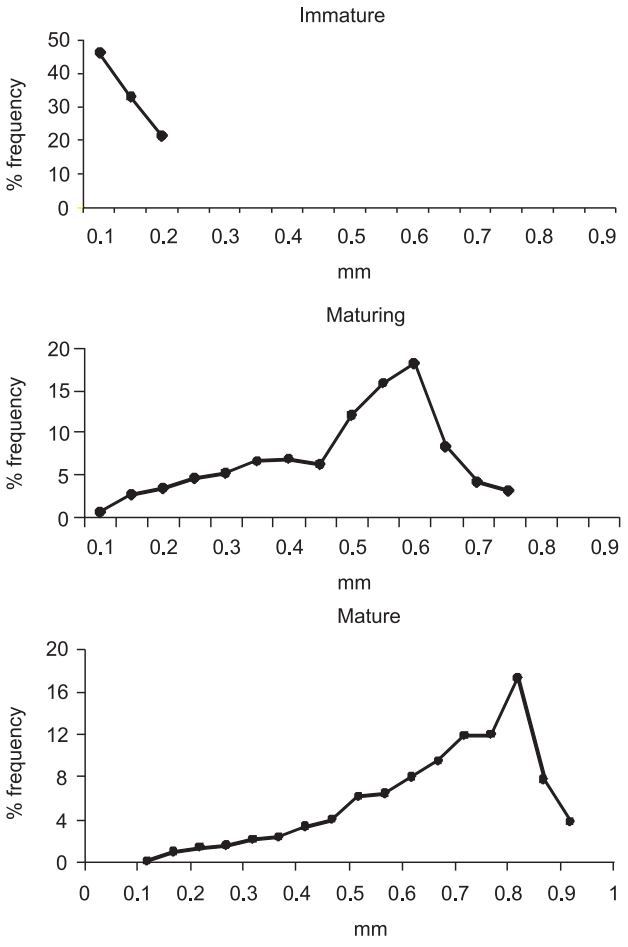

Fig. 3. Ova diameter of *S. inermis* in different stages of maturity

Jothinayagam (1981), Unnithan (1982), Silas *et al.* (1985b) and Talukdar *et al*. (1995) have recorded 'crustaceans' as the common food item and 'fishes' next in abundance, which is in accordance with the present findings from Mumbai waters but they are not agreeable with Oommen (1977) and Sarvesan (1996), who observed that this species fed mainly on 'fish'. The present investigation revealed occasional cannibalism, which was also observed by Silas *et al*. (1982). The preference for 'fish' in the months of February, May, September and between October-November may be attributed to more energy requirement post spawning. During the group sizewise analysis, the species showed preference for 'crustacean remains' in all the size groups but seems to have a slight preference for 'fish' in the size groups 20-39 (immature) and 55-69 (mature). The monthwise feeding intensity from Mumbai waters revealed that they are 'very active' just before the spawning seasons and during spawning they seem to feed very less which is evident by the GSI values and the large

Table 2. Monthly Gonadosomatic index, Nidamental gland index and Hepatic index of *S. inermis*

Month	Gonadosomatic index (GSI)		Nidamental gland index (NGI)	Hepatic index (HI)
	Male	Female	Female	Male-Female
January	1.68	6.51	9.80	4.63
February	1.73	5.92	7.04	8.55
March	1.68	5.24	6.28	8.54
April	1.68	5.74	7.59	5.89
May	1.45	4.66	6.70	7.67
June	1.39	4.24	5.59	6.04
July	—	—	—	—
August	1.63	4.65	6.19	5.69
September	1.68	4.53	6.36	7.88
October	1.58	6.37	9.87	5.07
November	1.64	4.85	6.91	7.76
December	1.60	3.35	4.57	8.05

number of 'empty' stomachs observed during January-February, April-May, August and October-November. Between the two sexes, females showed more 'active feeding' than males and this may be because the reproductive output of females is far higher and their metabolic requirements may be greater than that of males. According to Sarvesan (1996), active feeding was recorded in size group 80-84 mm. A similar observation was made in the present study with active feeding intensity in larger length group of 70-84 mm (spent), which may be to recoup the energy spent during spawning. In indeterminants, 60.4% of the stomachs were found to be 'empty' and this can be attributed to them having high basic metabolic rate, which seems to enable them to grow fast.

In the present study from Mumbai waters, the sex ratio of *S. inermis* showed dominance of females throughout the year which is also in agreement with Jothinayagam (1981), Unnithan (1982), Silas *et al.* (1985), Sarvesan (1996) and Neethiselvan *et al.* (2002). The variation in the sex ratio may be due to movement of the females to inshore waters for spawning. Immature and mature individuals were observed throughout the year, which was also observed by Jothinayagam (1981), Unnithan (1982), Sarvesan (1996) and Talukdar *et al*. (1995). According to Neethiselvan *et al*. (2002), the representation of wider length range with mature stages rules out the possibility of semelparity in this species. The size at first maturity in the present study was estimated at 48.06 mm for males and 55.04 mm for females, but according to Unnithan (1982), Sarvesan (1996) and Neethiselvan *et al.* (2002), the values are 51 mm, 47 mm and 45 mm for males and 31 mm, 58 mm and 45 mm for females respectively. From the observations made, it seems that the species in Mumbai waters (west coast) attains maturity at a comparatively larger size than other places (east coast).

According to the observations made by Unnithan (1992), Silas *et al*. (1985b), Talukdar *et al*. (1995) and Neethiselvan *et al.* (2002), occurrence of mature and immature stages throughout the year indicate prolonged nature of breeding habits. Sarvesan (1996) from Madras waters observed the dominance of males over females in stage II and III, with equilibrium at stage III that indicating that the sexes probably congregate together for courtship and spawning activities. From the present study it may also be inferred that this species exhibits prolonged breeding with four spawning seasons; January, April, July-August and October.

The ova diameter of *S. inermis* in the present study ranged from 0.38 to 0.79 mm and from 0.38 to 3.57 mm in immature and mature specimens respectively. The observed ova diameter values from Mumbai is less than those reported by Unnithan (1982) (0.67-2.24 mm for immature while 2.56-3.84 mm for mature) and Sarvesan (1996) (0.4-1.0 mm for immature and upto 3.81 mm for mature). The ova diameter percentage frequency polygon studies of *S. inermis* from Mumbai waters clearly shows one mode at larger ova diameter of 80-84 m.d (3.0-3.2 mm) indicating that spawning takes place only once during the spawning season as reported by Sarvesan (1996)**.**

According to Unnithan (1982), Sarvesan (1996) and Neethiselvan *et al.* (2002) the fecundity of *S. inermis* varied between 470-850, 380-590 and 437-684 ova respectively and in the present study, the fecundity ranged from 216 to 354 ova, which was less than those observed from other areas. This could be probably because *S. inermis* from Mumbai waters grow comparatively smaller in size and attain 'L_{∞}' faster because of intense fishing pressure. Sarvesan (1996) and Neethiselvan *et al*. (2002) commented that fecundity increased in direct proportion to the total length, which was also observed in the present study, but

there seemed to be not much relation between body weights to fecundity. It was often observed that sometimes females with smaller size and weight produced more number of eggs than those with larger size and weight. This may be attributed to the fact that *S. inermis* shed eggs in batches (Sivalingam, 1999) and therefore there is poor relation between total weight and fecundity.

Based on the observations made on this species from Mumbai waters it can be inferred that the species have four spawning seasons which is well supported by the values of GSI, NGI and HI. High values of GSI, NGI and HI indicate full development of gonads and low values indicate spawning activity. Based on GSI values, it seems that spawning was active during January, April, July-August and October. A similar trend of fluctuations in GSI was reported by Sarvesan (1996) and Neethiselvan *et al*. (2002). The nidamental glands become flaccid in spent condition, as the secretions from these glands are used to bind the eggs together and the HI decreases in spent animals.

Thus from the ongoing discussion, it is inferred that *S. inermis* from Mumbai shows allometric growth, feeding mainly on 'crustacean remains' followed by 'fish'. Based on the observations made by the maturity studies, condition factor, GSI, NGI and HI, it can be inferred that *S. inermis* has four spawning seasons *viz.,* January, April, July-August and October. The maximum number of indeterminants was observed in May-June ranging in length from 5-20 mm (Sundaram and Chavan, 2005), indicating that successful recruitment could be from the April spawning batch.

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References

Appanna Sastry, Y. 1989. Length-weight relationship in the cuttlefish *Sepiella inermis* Orbigny of Kakinada coast. *Indian J. Fish.,* 36: 175-176.

CMFRI, 2006. *Annual Report 2005-2006*. Central Marine Fisheries Research Institute, Kochi, 161 pp.

Hynes, H. B. N. 1950. The food of the fresh water sticklebacks (*Gasterosteus aculeatus* and *Pygosteus pungitius*) with a review of methods used in the studies of the food of fishes. *J. Anim. Ecol.,* 19: 36-58.

Jothinayagam, J. T. 1981. Studies on *Sepiella inermis* (Ferrusac and d'Orbigny) population occurring along the Madras coast. *Proc. Symp. Ecol. Anim. Populo Zool. Serv. India,* Pt. I: 83-89.

King, M. 1995. Fisheries Biology. Fisheries Biology Assessment and Management. *Fishing news book.*, p 107-111.

Kore, B. A. and Joshi, M. C., 1975. Food of the squid *Loligo duvauceli* d'Orbigny. *Proc. Indian Acad. Sci.,* 81B (1): 20-28.

Le Cren, E. D. 1951. The length-weight relationship and seasonal cycle in gonad weights and condition in the Perch (*Perca fluviatalis*). *J. Anim. Ecol.,* 20: 201-219.

Natarajan, A. V. and Jhingran, A. G. 1961. Index of Preponderance - A method of grading the food elements in the stomach analysis of fishes. *Indian J. Fish.,* 8 (1): 54-59.

Neethiselvan, N., Venkataramani, V. K. and Ramanathan, N. 2002. Breeding biology of the spineless cuttlefish *Sepiella inermis* (Orbigny). *Indian J. Fish*., 49(1): 97-101.

Oommen, V. P. 1977. Studies on the food, feeding and fishery of certain cephalopods from the west coast of India. *Bull. Dept. Mar. Sci. Univ. Cochin,* 8: 73-152.

Prabhu, M. S. 1956. Maturation of intra-ovarian eggs and spawning periodicities in some fishes. *Indian J. Fish.,* 3 (1): 59-90.

Rao, K. V. M., Alagaraja, K., Noble, A., Suseelan, C., Menon, N. G., Nair, K. Prabhakaran and Pillai, N. G. K., 1995. *A manual for standardised linear measurements of exploited finfish and shellfish*. CMFRI Kochi, 78 pp.

Roper, C. F. E., Sweeney, M. J. and Nauen, C. E. 1984. FAO species catalogue, Vol.3, Cephalopods of the world. An annotated and illustrated catalogue of species of interest to fisheries. *FAO. Fish. Synop.,* (125) 3:277 pp.

Sarvesan, R. 1996. *Investigation on the biology of two commercially important cuttlefishs* (*Sepia brevimana and Sepiella inermis*) *of Madras coast*. Ph.D. Thesis, University of Madras, 140 pp.

Silas, E. G. 1985. Cephalopod Fisheries of India-An introduction to the subject with methodologies adopted for this study. *In*: Silas, E. G. (Ed.). Cephalopod bionomics, fisheries and resources of the Exclusive Economic Zone of India. *Bull. Cent. Mar. Fis. Res. Inst.,* 37: 1-4.

Silas, E. G., Rao, K. S., Sarvesan, R., Nair, K. P. and Meiyappan, M. M. 1982. The exploited squid and cuttlefish resources of India: A review. *Mar. fish. Infor. Serv. T & E Ser.,* 34: 1-16.

Silas, E. G, Sarvesan, R., Nair, K. P., Appanna Sastry, Y., Srinivasan, P. V., Meiyappan, M. M., Vidyasagar, K., Rao, K. S., and Rao, B. N. 1985. Some aspects of the biology of cuttlefishes. *In*: Silas, E. G. (Ed.) Cephalopod bionomics, fisheries and resources of the Exclusive Economic Zone of India. *Bull. Cent. Mar. Fis. Res. Inst.,* 37: 49-70.

Sivalingam, D. 1999. Successful breeding and hatchery experiments of the spineless cuttlefish *Sepiella inermis* at Tuticorin shellfish hatchery. *Mar. fish. Infor. Serv. T & E Ser.*, 161: 11-13.

Sundaram, S. and Chavan, B. B. 2005. A note on the landings of juveniles of *Sepiella inermis* at Mumbai. *Mar. fish. Infor. Serv. T & E Ser.*, 186: 18-19.

Talukdar, S., Chatterjee, T. K., Ramakrishna and Brahmachary, R. L. 1995. The biology of cephalopods (Decapoda) at Digha coast (West Bengal). *Rec. Zool. Surv. India*, 95 (1-2): 31-55.

Unnithan, K. A. 1982. Observations on the biology of cuttlefish *Sepiella inermis* at Mandapam. *Indian J. Fish.,* 29 (1 & 2): 101-111.

Zar, J. H. 1999. Comparing simple linear regression equation. *Biostatical analysis*, Fourth edn. Pearson Education., Inc., 360-376.

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